LIGHT RAIL

AN OVERSEAS CHALLENGE FOR AUSTRALIA.

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INTRODUCTION AND DEFINITIONS

In your neighbouring capital city of Melbourne, the humble tramcar continues daily to move very large numbers of people along the streets, quietly, efficiently and without pollution. I guess that, as a Melbournian, I have some pride that Melbourne, alone of all Australia's capital cities, has seen fit to maintain a full-scale tramway system.

During 1976 it was my great privilege to spend 13 weeks overseas. The fundamental purpose of my trip was to study developments in all forms of land-based passenger transport. Of all that I saw and learnt, nothing impressed me more than that the humble tramcar is no longer so humble. It is enjoying a rebirth of incredible proportions and in so doing has earned for itself a new name - LIGHT RAIL.

What is Light Rail? This is a difficult notion for Australians to comprehend. The Seminar, as you and I have known it, is certainly part of light rail. But in Australia we have "railways" and we have "tramways" and we believe that we know the differences between the two. But true light rail is intermediate between those two technologies.

The Germans have their terminology much better detailed because, instead of two, they use no less than five terms:-

- Bundesbahn - conventional heavy railway (e.g. the ANR in S.A.)
- S-bahn - suburban railway (e.g. STA train in Adelaide)
- U-bahn - urban railway (e.g. London underground)
- Stadtbahn - light rail (about which we will say much)
- Strassenbahn- street tramway (e.g. MMTB in Melbourne)

Now, although Melbourne may have Australia's only remaining street tramway (strassenbah)system, the only real example of light rail to be found anywhere in Australasia operates between Victoria Square and Glenelg in your beautiful capital city of Adelaide. With its fast large tramcars, reserved ballasted track, protected level crossing and developed terminals, your Bay Line is light rail. So Adelaide people,more than any in Australia, can understand and comprehend the light rail concept.

J. William Vigrass, Superintendent of Equipment, Port Authority Transit Corporation (PATCO), Philadelphia, U.S.A., tells us that "light rail is an evolutionary development of the street railway and full scale rapid transit" and that it "is a medium cost, medium speed, medium volume, railed transport mode".

I have often defined light rail simply as small trains on small headways. (The headway is the frequency or time between following vehicles). Terminology can get very confusing.

A private railway is often called a tramway. You have all heard, for instance, of the timber tramways that once radiated into so many of our forests.

The American "tram" is a small bus pulling one or more trailers. Our tram is their "streetcar" or "trolleycar" or just "trolley". The "trolley bus", as we knew it, is known in America as a "trackless trolley" and is also enjoying a revival, but that is another story.

Before we really start to study the nature and advantages of light rail, it is very pertinent to ask why it is enjoying such universal popularity. I shall therefore try to paint the surroundings and background of our picture before I paint the technology into it.

THE PRIVATE MOTOR CAR

There is no doubt that the private motor car has brought many gains to our society. It has enabled us to make journeys that public transport cannot provide. It has increased our opportunities to visit friends, for shopping, to tour Australia. It has given us increased independence. It will tow our caravan or our boat. It has made a very great contribution to our mobility and to our living and it must continue to do so.

But we have made a very big mistake when we thought that the car, alone, could solve all our transport needs.

Ken Ogden, Lecturer in Transport at Monash University, Melbourne, refers to the YOPHS - the Young, Old, Poor and Handicapped, to whom the car is inaccessible. They still need public transport and their need of mobility is as great as any of the more fortunate of us who own our own cars.

54% of all people in the suburbs of all English cities in 1973 had no access to a car![2.] In Manchester in 1971 the city fathers realised that they were spending 80% of their transport capital on roads for 50% of the people. 40% of all Americans are YOPHS. Terence Bendixson in his excellent book "Instead of Cars" [3]reports that, after an upgrading experiment on the buses in Stevenage, England, "Elderly people and children were unchained from their houses".

But people were also becoming worried about the hidden costs of private car transportation - the loss of life, injuries, law enforcement, parking space, hospitals, legal costs, repair facilities, pollution protection, noise abatement and, not least, the loss of rateable property.

The car is a frighteningly inefficient user of space. In Los Angeles (I know that it is the inevitable comparison) 59% of all land in the Central Business District (CBD) is used for streets and parking. That leaves less than half of the land for the vital real functions of a city of people. If all our own city workers drove their cars to work, three floors out of five in every building would be needed for parking.

In a half hour traffic census by the Town and Country Planning Board[4] on Princes Bridge, Melbourne, during the height of the peak period, one tram track carried 5,500 people while the two parallel road lanes carried only 727, "a ratio of 15 to 1 in favour of trams".

For the year 1972 the House of Representatives in Canberra estimated that road accidents cost Australia between 650 and 850 million dollars.[5] For the same year in Canada, we are told that 4076 people died from gas. "29 inhaled it, 47 put a match to it and 4000 stepped on it".[6]

Perhaps even more alarming is the realisation that, in Victoria in 1973, 53-6% of all deaths to people 15 to 24 years of age (inclusive) were caused by road accidents

Then, and by no means least, there is the energy problem. The world that you and I live on is fast running out of liquid fuel. We must start planning for a time not far away when not only will petrol and oil become very scarce but also very expensive and we will not be able to commute around in our cars the way that we do now. Allow me to quote at length from the Financial Review.[8]
"Various modes of public transportation consume up to 20 to 40 times less energy than private motor transportation, while during the last 30 years the subsidies for freeways have been 20 to 30 times larger than the subsidies for public transportation.

Hence conversion from private to public transportation offers an energy conservation alternative of unparalleld scale."

Perhaps the oil companies could be expected to favour the car so that they can sell more fuel and make larger profits. Some companies, however, do appreciate the problem and, as one well-known company puts it,[9] "while Mobil sells fuels and lubricants, we don't believe the gasoline consumed by a car idling in a traffic jam is the best possible use of America's limited petroleum resources. Our products ought to help more people get where they want to go. To us, that means the green light for mass transit .....soon".

The car, therefore, brought with it problems. Real problems. There was still no doubt that the car is important, but the real challenge was to find another transport mode that could co-exist with the car and effectively replace the need for many of its journeys.

GEE-WHIZZ

So along came the "Gee-Whizz" Technologies. I have borrowed that apt term from Bendixson.

The monorail looked good. It was fast, clean and modern. It fitted the environment. But cost-wise it was very expensive. Technically it could function quite well on a single route (as to Tokyo's Haneda Airport or Seattle's World Fair) but points and junctions were a real problem as the large pre-stressed concrete beams that form the track are very hard to move. So nowhere in the world has it been possible to construct a real monorail system.

In Wuppertal (Western German,) a hanging or suspended monorail (Schwebebahn) operates very successfully but still on a single route. It is locally acceptable because there was no space on the ground for any other type of system.

The initials PRT stand for Personal Rapid Transit. This technology has small computer operated vehicles that speed you to the destination on your magnetically coded ticket or that you indicated by pushing a button. In Morgantown, West Virginia, U.S.A., an intriguing and praiseworthy set-up has 8-seater cabins on rubber tyres, propelled by linear induction electric motors and magnetically steered at turn-outs. But headway is 7½ seconds, which, allowing for some standers, gives 5000 people per hour (pph), good enough only for small cities.

There were likewise limitations with all the revolutionary new technologies. Was the answer with an older, well tried and proven technology, capable of evolution instead of revolution?

Yes world, it was and is, for here was one humble tramcar, waiting in the wings of the stage to re-enter the spotlight as a Light Rail Vehicle.

Light rail was not new. In fact the world's first true light railway (LR) was probably the Manx Electric Railway which commenced operation between Douglas and Howstrake, Isle of Man, on 7th September, 1893. In Boston, Massachussetts in 1897 a single truck tramcar wobbled down into the darkness under Park Street to initiate the world's first LR subway.

Remembering that an efficient transport system must be a co-ordinated network of different modes, let us look exactly at light rail to see how it really does compare with other public transport modes such as train and bus.

ENERGY

In Victoria [10] the passenger kilometres travelled for each kilowatt hour of energy used are:-

Private cars	0.92
Electric trams	6.73
Electric trains	8.20

Interpretation of figures for the UK [11] enables us to add:-

Walking	2.5
Bicycling	10.0
Buses	5.0

The trains show better energy usage to trams only because of the longer spacing between stops and the lack of stop-start operation in traffic jams.

Is it not very obvious? The energy used by trams can be reduced by segregating them from road traffic and by increasing the distance between stops. These are two of the basic principles of light rail.

As you are probably well aware, Melbourne already has in service nearly 100 new trams of orders for 215. These are the orange Z-cars. They are in fact Light Rail Vehicles (LRV's) but they are still operated as street tramway vehicles.

The last 100 of these units are to have an entirely different type of control. By using thyristor pulse-control (chopper) equipment instead of the older resistances energy previously wasted as heat will be conserved. Moreover, the vehicles will be equipped with dynamic braking which by regeneration (changing the motors into generators) will return up to 45% of the drawn power to the overhead wires.[12]

These modifications will put these LRV's in the lead with cycling as the most energy conservative transport mode.

VEHICLES (the LRV's)

The true LRV is a modern, lightweight, saloon unit capable of reasonably high speeds on relatively light track. Comfort, air conditioning, tinted windows and fluorescent lighting are normal. Bodywork is usually steel, but aluminium and fibre glass are possibles.

It can be a simple bogie vehicle of 4 axles. The present wooden framed Glenelg trams are of this type but despite the beautiful restoration work which has been applied to those which have been refurbished, I don't really think that we should call them modern.

More usually the LRV is articulated. If you were to take two Glenelg trams, chop one end off each and then connect the two now-open ends together with an in-built turntable and a bogie below it, you would have a 2-section, 6-axle, articulated LRV unit.

The ultimate in this development must surely be the 5-section, 12-axle units of the Rhine - Haardtbahn in Western Germany.

The capacity of an articulated unit is obviously very much greater than that of a normal bogie car and is limited only by the number of sections in the unit. Now, if the unit still does not satisfy your need for peak capacity, you can put two units together or you can have your unit tow a trailer (or two). This gives flexibility in capacity without increasing staff.

Although the RHB operates with a conductor, most European LRV's have only the driver. Therefore you have only one employee responsible for the trnasport of up to 300 or more people, a great saving in these days of high labor costs, and such savings mean cheaper fares.

The new Boeing Vertol (BV) LRV's for Boston have a maximum capacity of 219 passengers, or 438 for a 2-unit set.
One of the disadvantages of conventional heavy railway systems is the lack of supervision of passengers both on trains and at stations in off-peak times, resulting in vandalism, nuisance, bashings, robbery etc. LRV's, in retaining the driver in the unit with the passengers, provide safety for all travellers. The driver is in radio contact with control base at all times as in Adelaide's public transport vehicles. Trailers or second units are not used in off-peak so there is no supervision problem with them.

LRV's are capable of up to 100 km/h and, although the ride is dependent on the track, the large number of wheels (12 in a 2-section articulated unit) give a much smoother ride than the 4 wheels of a bus.

Modern controls give "stepless" acceleration without the gear changes of a bus or the notches and transitions of older tramcars

The units draw electric power from an overhead wire, normally through a pan and pantograph rather than a carbon shoe or trolley wheel and pole. Pantographs do not dewire as can poles and they do make for simpler overhead wiring and junctions.

This power for the LRV comes through the wire from an external power source as distinct from buses and cars that carry their power unit with them. Therefore the unit is completely pollution-free. It gives off no emissions, leaves clean air for us to breathe and makes no contributions to the visual smog in which we live. Think how the views would improve in a city that burns no fossil-fuels.

"Since Brisbane had switched from trams to buses .... pollution had increased to the point where Brisbane City Council had had talks with bus operators to try to cut down exhaust fumes." 13.

Another advantage of the external power source is that air conditioning does not decrease the power available for traction. The performance of a bus is severely reduced by having the engine power the airconditioning as well as the bus.

Floor heights are low and steps are easy for older citizens and the handicapped to mount and demount.
The ultimate in comfort is provided in some of the splendid Düwag LRV's in Dusseldorf, Western Germany. These 3-section units even have a buffet in the centre section!
Modern LRV's are so quiet that their silence almost makes them dangerous. Notwithstanding drivers with musical gongs, you just cannot hear them coming. Helical gears, rubber inserts sandwiched into resilient wheels, chevron type rubber suspensions, carbon skid plates on the pantograph pans, all make for quiet operation. If that is not enough, steel rails, on timber sleepers or on rubber pads on concrete sleepers, in ballast is a system capable of dampening out its own noise. If the rails are to be placed in concrete they can be encased in poly-urethane or similar as at St. Kilda Junction in Melbourne.

The LRV has, of course, nowhere near the weight of a railway carriage. This reduces maintenance costs of both vehicle and track. An LRV has an estimated life of 30 years.

Comparing with a diesel bus we find an 8 to 1 passenger kilometre advantage in the life of a vehicle.

	LRV	BUS	RATIO
Life (years)	30	15	2 to 1
Average speed (km/h) inc.stops	40	20	2 to 1
Capacity (people)	150	70	2 to 1

(both capacities are based on non-articulated units).

SAFETY

Parker [14] also has a table wherein he compares the safety of passengers.
For the U.S.A. the death rate per million miles travelled is:-

Motor cycle	1.25
Cars on all roads	0.048
(Cars on freeways)	0.025)
Buses	0.0017
Railed transport	0.0004

You are 4 times safer on an LRV than in a bus and 120 times safer than in a car.
One of the great advantages of the rail and flanged wheel is that they steer the unit (derailments excepted). You do not get lost in fog, slip sideways in the wet, get washed away in floods, or collide with oncoming units.
The steel wheel on steel rail is a low friction system which assists energy

conservation yet does not inhibit braking. Most LRV's have 3 braking systems. All the new BV units in the U.S.A. have dynamic motor braking, pneumo-hydraulic disc brakes and electro-magnetic track brakes. The last involve shoes which clamp magnetically to the track in emergency. They can even be too efficient. Cases are known where the shoe has welded itself to the rail and has had to be cut loose to free the tram.

TRACK

It is in this field that some of the most incredible advantages of light rail become apparent. Flexibility and versatility are the magic words.

With normal adhesion (i.e. without the assistance of a rack rail) grades of up to 8.6% (as on the San Francisco Muni) can be achieved compared to about 3% only on a conventional railway. Curves can be as sharp as 13m radius.

The superior light rail track is a ballasted track on private right-of-way completely grade-separated from all other transport modes. Stops are up to a kilometre apart, thus high average speeds can be obtained. The Riverside line in Boston, the Norristown line in Philadelphia and the Duisberg line from Dusseldorf are all excellent examples.

If grade-separation is not financially or topographically possible, you can still have level crossings, preferably protected by traffic signals and/or boom barriers as on the Glenelg line.

If that is not possible you can still run in mixed traffic in the street, or better, at the side of the street. Vienna, Rotterdam and Brussels all use the latter technique. I believe though that it is essential for the greater part of the LR journey to be off-street for thorough efficiency.

If light rail must (reluctantly) be operated in the middle of a mixed traffic street, then an attempt to discourage motor vehicles from the track area is still recommended. On the Judah line in San Francisco the tracks are set in concrete which is about 100mm above the rest of the road surface. In many cities (Amsterdam is one) low mountable kerbing is used as a separator. In Melbourne where an experiment with this technique has been tried in Nicholson Street, a 50% reduction in tram delays between stops and (surprise) an increase in average motor vehicle speed from 19 km/h to 25 km/h have resulted. [15]

Light rail is equally at home in tunnel, on viaduct, in the median of a freeway, under a freeway, beside a river. It is this flexibility of route which appeals greatly.

The Shannon lines in Pittsburgh, U.S.A. are an excellent example. The units start in the outer suburbs at park and ride interchanges. They then proceed on separated track through hill suburbs like the Victorian Dandenongs or your Mount Lofty Ranges, over viaducts and bridges to South Hills. Here they dive through a tunnel, emerge over the Mononghela River on their own bridge right-of-way, and move through the CBD in street centre.

Another interesting American example of route versatility is the Shaker Heights line in Cleveland, Ohio, where the LRV's enter the CBD by sharing tracks and overhead with a conventional railway!

The CBD offers so many route alternatives. Some cities (Brussels, Stuttgart, Vienna, Boston, Philadelphia and soon San Francisco) put their LRV's underground for speed and reliability of schedule and for protection from weather. Other cities keep the LRV's on the surface remove motor vehicles, and have large pedestrian/ transit precincts (malls) (Zurich, Bremen, Mannheim). Pedestrians use the LRV's as a means of mobility within the precincts. After all, people movers should be where the people are. In some cities the LRV's are routed through buildings (Ludwigschafen, Milano).

LRV's are imminently more suitable than buses in pedestrian/transit precincts. There is less noise, no pollution, and the LRV does not stray from its tracks. In tunnel, on viaduct, in narrow transit lanes the self-steering LRV is again much safer. Try riding a Sydney bus over the Iron Cove Bridge transit lane in the afternoon peak. LR would go well through the Wooloongatta, Q. bus tunnels - not always so with the buses.

Finally, on this theme, I am in no doubt that a ballasted track is more environmentally acceptable than a sealed roadway.

LRV stops vary immensely from a simple sign on a pole, a protected safety zone in the street, a platform, a proper station. But here again an advantage over conventional railways in that stops do not need to be manned.

OVERHEAD AND SIGNALLING

Overhead wiring can indeed be visually obtrusive. It has been simplified slightly by the use of pantographs but I still prefer wires to fumes.

Light rail routes can overcome this problem by using a third rail pick-up (e.g. the Red Arrow line to Norristown, Philadelphia). In such cases though complete grade separation is essential.

Light rail signalling can be trackside (as with conventional railways), permissive (trackside and non-regulatory, really only indicates how far ahead the previous unit is), "on-sight" (no signals at all) or cab.

Cab signalling, where the signal indications appear on the driver's console, is being installed for the new Market Street subway of the San Francisco Muni "On-sight" signalling is quite sufficient for most light rail applications, provides shortest headways and uses least manpower (no signalmen).

Points are operated from within the LRV's. Considerable research is being done on vehicle control systems in which a coded device is placed on the LRV, read by wayside detectors (very difficult with buses), assimilated by a computer which activates points and desination indicators at stops, and advises a central controller of serious hold-ups or out-of-sequence operation which it cannot solve itself.

STANDARDISATION

Do you realise that, 20 years ago, Brisbane had locomotive hauled suburban trains on 3'6" gauge, Sydney electric on 4'8½", Melbourne electric on 5'3" and Adelaide diesel railcars on 5'3"? All different. Yet at the same time the tramways in those same cities were all 600 volt DC overhead current on 4'8½". Completely standardised.

The same still holds true today and standardisation of light rail technologies throughout the world means effective co-ordination of design and development and greater availability of vehicles and parts.

SOME PARTICULAR APPLICATIONS OF REAL NOTE

In Boston, U.S.A., a city of 2,700,000 people, the MBTA (Massachussetts Bay Transit Authority) in 1959 took over the locomotive hauled railway to Riverside and have converted it to a magnificent LR facility. The track is fully grade separated and enters the CBD through the light rail subway. On these tracks the new BV LRV's are already operating. This very successful operation shows that LR can often do the task of conventional rail and do it better.

In San Francisco, U.S.A., tracks are being upgraded on the Muni (Municipal Railway is their LR system) and the present surface tracks are being placed underground along Marker Street, the city's main thoroughfare, in a co-ordinated route with the Bay Area Rapid Transit (BART) U-bahn trains. The BV LRV will also operate here.

Rotterdam (Netherlands) has a magnificent system. The articulated units are kept in immaculate condition, the crews show a great pride in their task, and the environmental work is outstanding. It is interesting how evolution has turned full cycle in

LIGHT RAIL

Rotterdam. The first tram subway opened as a metro railway or U-bahn. The next subway planned for the metro will instead open as - yes, light rail.

In Dusseldorf (Western Germany) the Düwag LRV's run on light rail systems to Krefeld and Duisberg. From Duisberg, successive LRV's will then take you intercity hopping to Mulheim, Essen, Gelsenkirchen and Bochum through the Ruhr Valley. A similar intercity system is operated between Mannheim and Heidelberg over two separate routes, by the OEG (Oberrheinische Eisenbahn Gesellschaft) and is fully signalled.

A new Canadian LRV is being designed for Toronto and will soon find application in Edmonton, Calgary and Winnipeg.

COST

Light rail is obviously less costly in the construction of both vehicles and track than conventional rail. What about operation?

Consider the following Australian cost/revenue ratios [16] -

Suburban railways	1.75 to 1
State bus services	1.67 to 1
Tram services	1.36 to 1

The LRV (alias the tram) leads the economy field easily. (You were probably not surprised to see that cost exceeds revenue in all cases.)

Sydney's Eastern suburbs Railway currently under construction (part of the suburban "S bahn" network) with underground and elevated sections and fully grade-separated, was becoming almost prohibitively costly to construct. The work hesitated while the whole project was given a rethink.

Indicative of the flexibility of LR was the proposition that the railway as already built be converted to LR to cut back the enormous construction and operation expenditures that were ahead. The LRV's could then have emerged from the underground station at Bondi Junction (the immediate terminus) to proceed along the streets and former tramway reservations to the Eastern suburbs. In brief this would have achieved the same task that the railway connecting with buses will do and would have eliminated the inconvenience of the trams/bus interchange.

But it was not to be. Sydney nearly had its "trams" back.

It is fairly important to realise that LR is not as technically complex as a conventional rail system. This is economically beneficial in itself. But it also means that there is less chance of malfunctions. Every major malfunction is costly to fix and also helps to discourage passengers. Every lost passenger is lost revenue. The LR system avoids many malfunctions and also the immediate cost of overcoming them and wins passengers and hence revenue through reliability.

CAPACITY

In terms of people moved per hour on one track (pph):

PRT Morgantown	5000 (refer earlier)
Light Rail	12000
Victoria Line, London	24000

The Victoria Line is a fully automatic underground urban railway (U-bahn) and is probably as practically efficient as a railway can be.

Bus figures are not included as buses tend to use more than 1 lane and very seldom operate to capacity, thus making any figure and comparison rather hypothetical.

The LR figure is really conservative. If the BV LRV's in 2-unit sets fully loaded (400 persons) moved past at 1 minute headways, you have 24,000 pph, right up with the best of railways, but I do feel that if such loadings were offering then only conventional rail could provide for an overload factor or for future increases in passenger volumes.

TO THE HILLS

Those wonderful Germans have another word for us - "bergbahn" or mountain railway. Puffing Billy in Victoria is a "bergbahn" but many overseas "bergbahnen" operate as LR systems, often with a rack rail to assist traction.

This is really a paper on city transportation, but the use of LR in the hills (the Jungfraubahn in Switzerland attains an altitude of 3454m (11,333 feet or 1½ Kosciusko's) is worth the mention as further indication of their incredible flexibility.

SUMMING UP

The advantages of light rail are:

1. Least use of energy
2. Economic track construction
3. Versatility and flexibility of track location.
4. Economic operation and low maintenance
5. Low labor intensity
6. Low fares

7. Medium to high speed
8. Medium to high capacity
9. Pollution free
10. Quiet smooth operation
11. Low noise
12. Comfort
13. Visually and environmentally attractive
14. Safe travel and effective braking
15. Direct supervision of passengers
16. No or little necessary signalling
17. No conventional stations necessary.
18. Intensive use of space
19. Desirable segregation from other traffic
20. Electric with off-vehicle external power supply
21. Convenient
22. Regular and reliable

CONCLUSION AND CHALLENGE

Light rail is the superior form of urban land transport. It is a proven transport mode being evolved from train and tram.

It is not intended to be a modal monopoly. No one transport mode can ever be this. But there is a real function for light rail to play in conjunction with other modes in all large Australian cities today.

Australia! The world challenges you to accept light rail technology.

Melbourne! With your effective sections of light rail trackwork, your Z-cars and your efficient tramway system -how lucky you are.

But Adelaide! Back in 1966 the following appeared in the magazine "Electric Traction."[17]

> "The Glenelg line with its H-class cars continues to be operated on little more than a day to day basis, leaving little real hope for its future".

Little real hope? Somehow your Glenelg line has survived to this day. Not only has it survived but the 40 year old tram cars have been refurbished, crossings have been protected, termini have been improved. Someone, somewhere, in your City, has foreseen all that we have been discussing and realised that the apparently anachronistic tramway to Glenelg was, in fact, the type of transport that the world was to develop and applaud.

To you there now comes the tremendous opportunity to extend the Glenelg service to the north east as a full light rail facilitiy, with fine new modern vehicles and implementing the best of overseas technology. To no other city in Australia falls such an opportunity.

It is a challenge which I hope that you will take. It is the challenge, Adelaide, to provide transport leadership to all of Australia.

REFERENCES

1. "Electric Traction", Feb 1976

2. Mayer Hillman, "Personal Mobility and Transport Policy,"London 1973.

3. Terence Bendixson, "Instead of Cars," Penguin, London, 1976

4. Major General Sir Robert J.H. Risson, Presidential Address to the Institution of Engineers, Australia, Journal of the Institution, June,1963

5. Electric Traction" Jan. 1978

6. "Truck and Bus Transportation", Nov.1973

7. "Truck and Bus Transportation" March 1975

8. Christopher Jay, "Financial Review," Oct. 14, 1977.

9. "Railway Transportation", Feb. 1971

10. F. Dudley Snell, Chairman, MMTB, "Transport Victoria", Proceedings of Seminar held at the Transport Regulation Board, Melbourne, 4th August,1977 (Chartered Institute of Transport).

11. Alan Parker, "Inventing the Bicycle" October, 1974.

12. F. Dudley Snell, as above

13. Milton Morris, previous Transport Minister, N.S.W. at a meeting in Melbourne

14. Alan Parker, as above

15. "Electric Traction" Jan. 1977

16. D. Bayliss, Chief Planner (Transportation), Greater London Council after visit to Australia, "Traffic Engineering and Control", July 1976

17. "Electric Traction". Dec. 1966